The Global Hawk Pacific Mission (GloPac): Demonstrating unmanned aircraft technology for Earth science research

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25 October 2009
NASA DFRC

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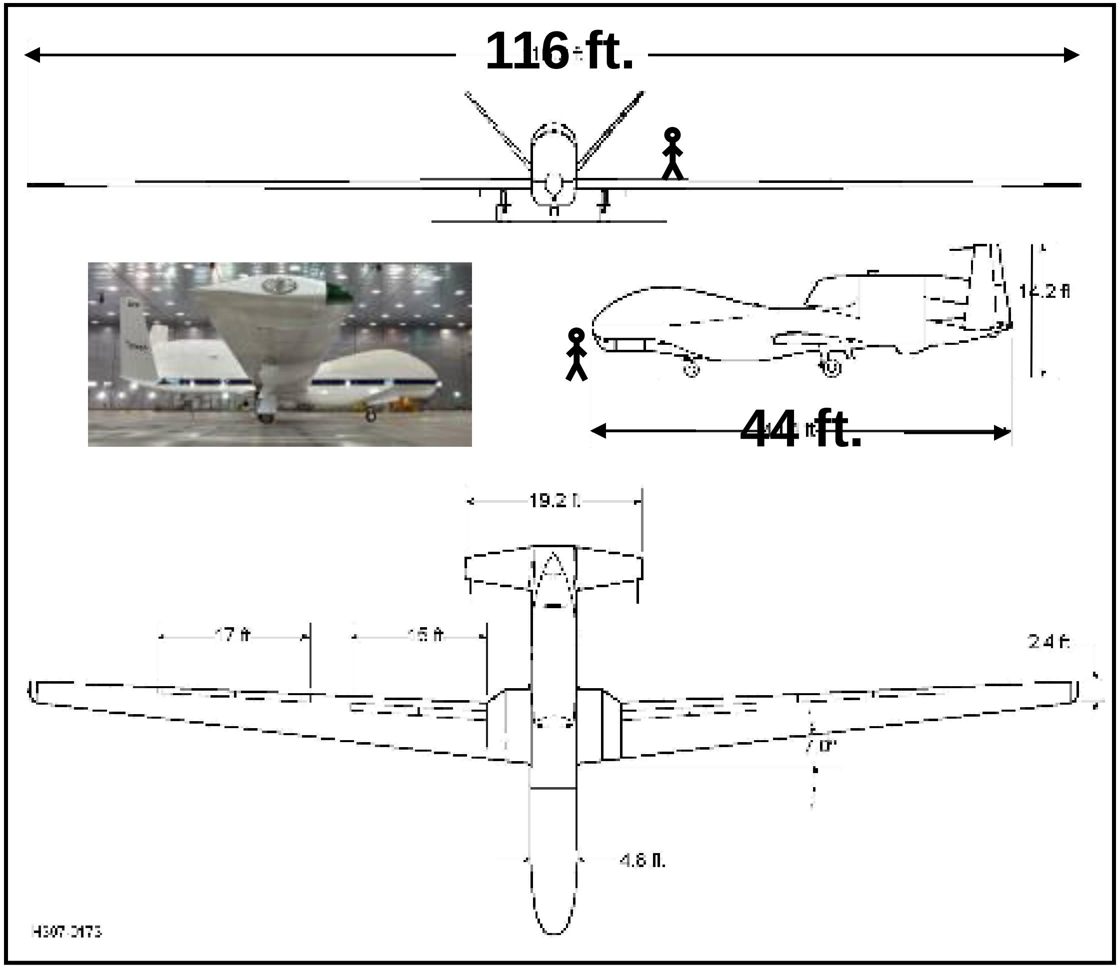
Outline:
- Global Hawk UAS Basics
- GloPac & some science results
- Future Missions - ATTREX, HS^3

NORTHROP GRUMMAN

NASA
Global Hawk Pacific
GloPac 2010

The Global Hawk is a fully autonomous aircraft system



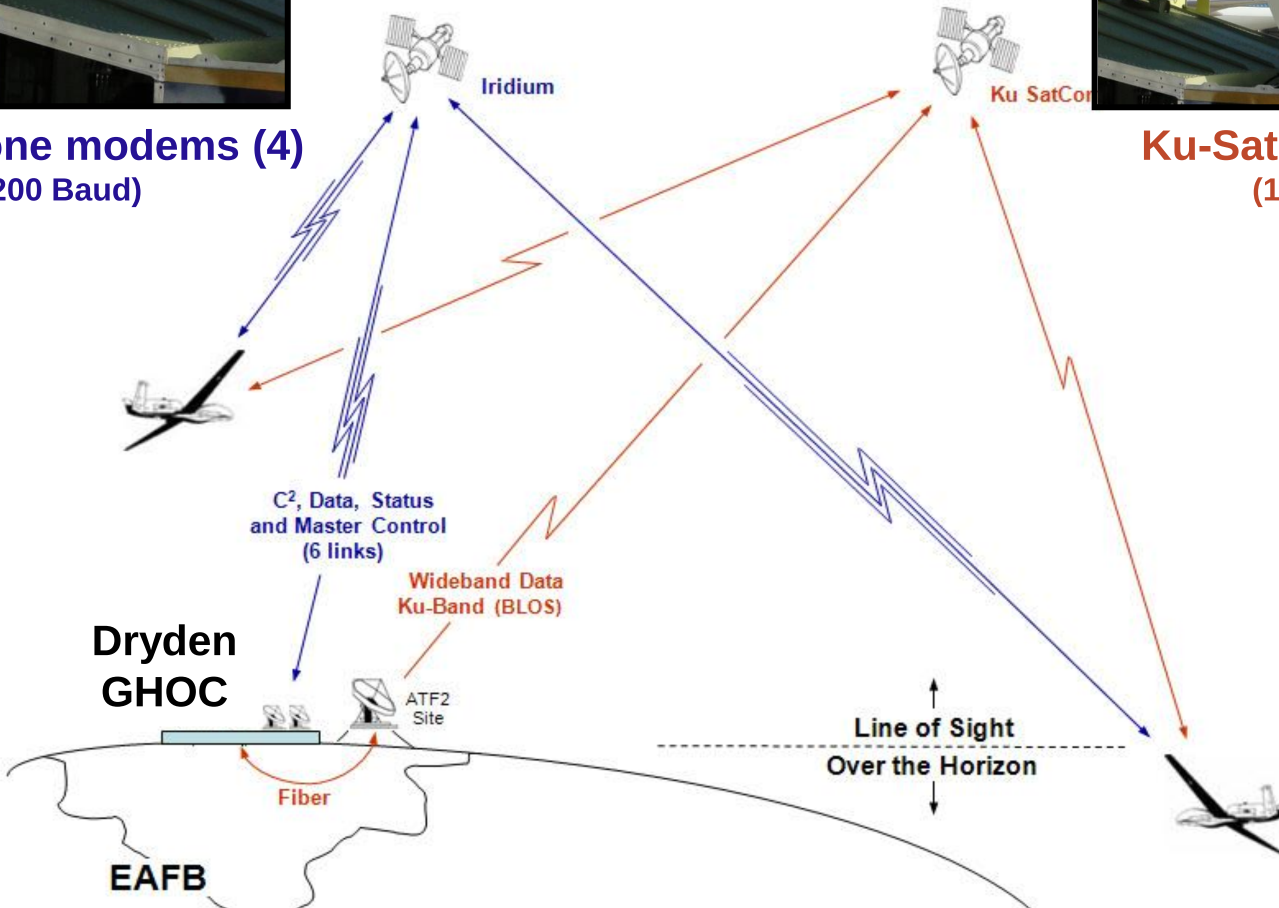
GH Specifications	
Wingspan	116 ft
Nominal Range	> 10,000 nm, 18,520 km
Endurance	> 30 h
Max. Cruise Altitude	65,000 ft, 19.8 km
Gross Weight	26,750 lbs., 12,134 kg
Fuel Capacity	15,300 lbs., 6,940 kg
True Airspeed	335 kts, 172 m/s, 386 mph
Payload Weight	1500 lbs., 680 kg
Payload Power	10kVa
Payload Volume	> 175 ft^3, 5 m^3

65,000 feet = 19.8 km = 56.5 hPa

Payload Communications

Iridium phone modems (4)
(19,200 Baud)

Ku-SatCom antenna
(1 – 5 Mbps)



Global Hawk ←→ Global Hawk Operations Center → World Wide Web

Global Hawk Operations Center (GHOC)

View of the GHOC from the Payload Operations Room

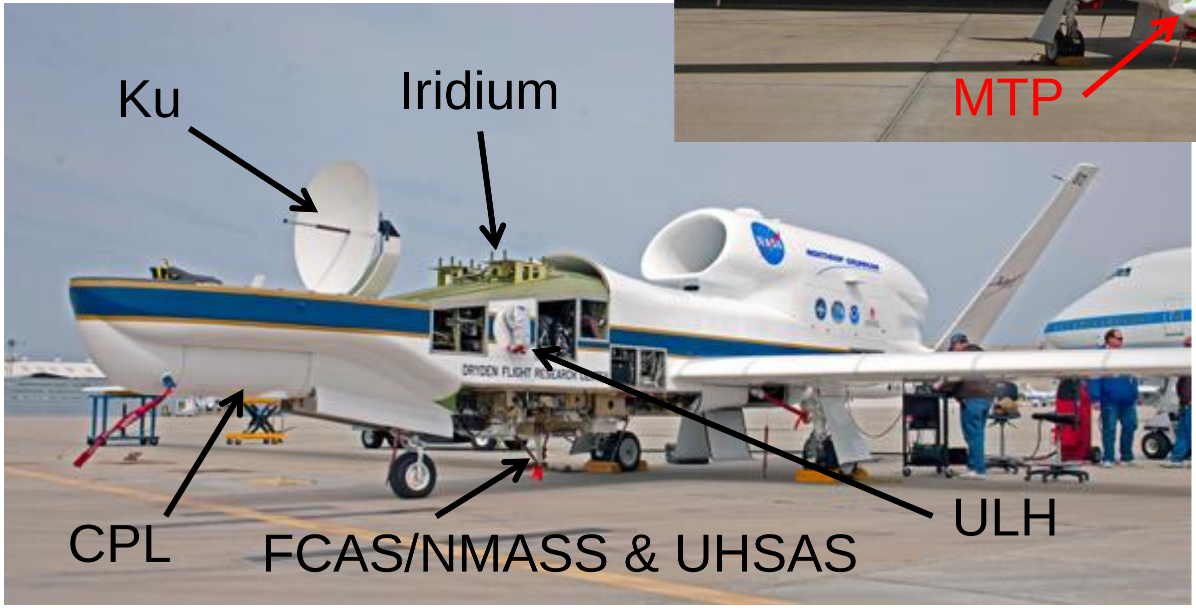
GloPac Objectives

- First demonstration of the Global Hawk unmanned aircraft system (UAS) for NASA and NOAA Earth science research and applications
  - Development of science-operation protocols & procedures
  - Long duration Pacific Ocean and Arctic flights
- Exploration of trace gases, aerosols, and dynamics of remote upper troposphere and lower stratosphere regions
  - Aura satellite instrument validation
  - Sample Arctic vortex fragments, and aerosol/dust plumes

- Establish needed capabilities not in Air Force repertoire
  - Vertical profiling capability
  - Flights to polar latitudes
  - Flights in cold temperatures (fuel issues)
  - Flights in convective regions

GloPac Configuration

GloPac instruments are located in various payload bays on the aircraft. Inlets for trace gases are indicated by the “red” flag covers



Communications are key to both the aircraft’s operation and the transmission of data. Iridium and Ku provide both uplink and downlink comm and data links.

GloPac Instrument Payload

In situ sensors

Stratospheric tracers	
ULH H_2O	JPL (Herman)
NOAA O_3	NOAA ESRL (Gao & Elkins)
Long-lived gases	
UCATS N_2O, SF_6, CO, H_2, CH_4	NOAA ESRL (Elkins)
Aerosols	
NMASS (0.004 – 0.60 μm diameter)	U Denver (Wilson)
FCAS (0.09 - 1 μm diameter)	U Denver (Wilson)
UHSAS (0.05 - 200 nm diameter)	DMT, Inc (Gandrud)
Meteorological parameters (P, T, winds)	NASA Ames (Bui)

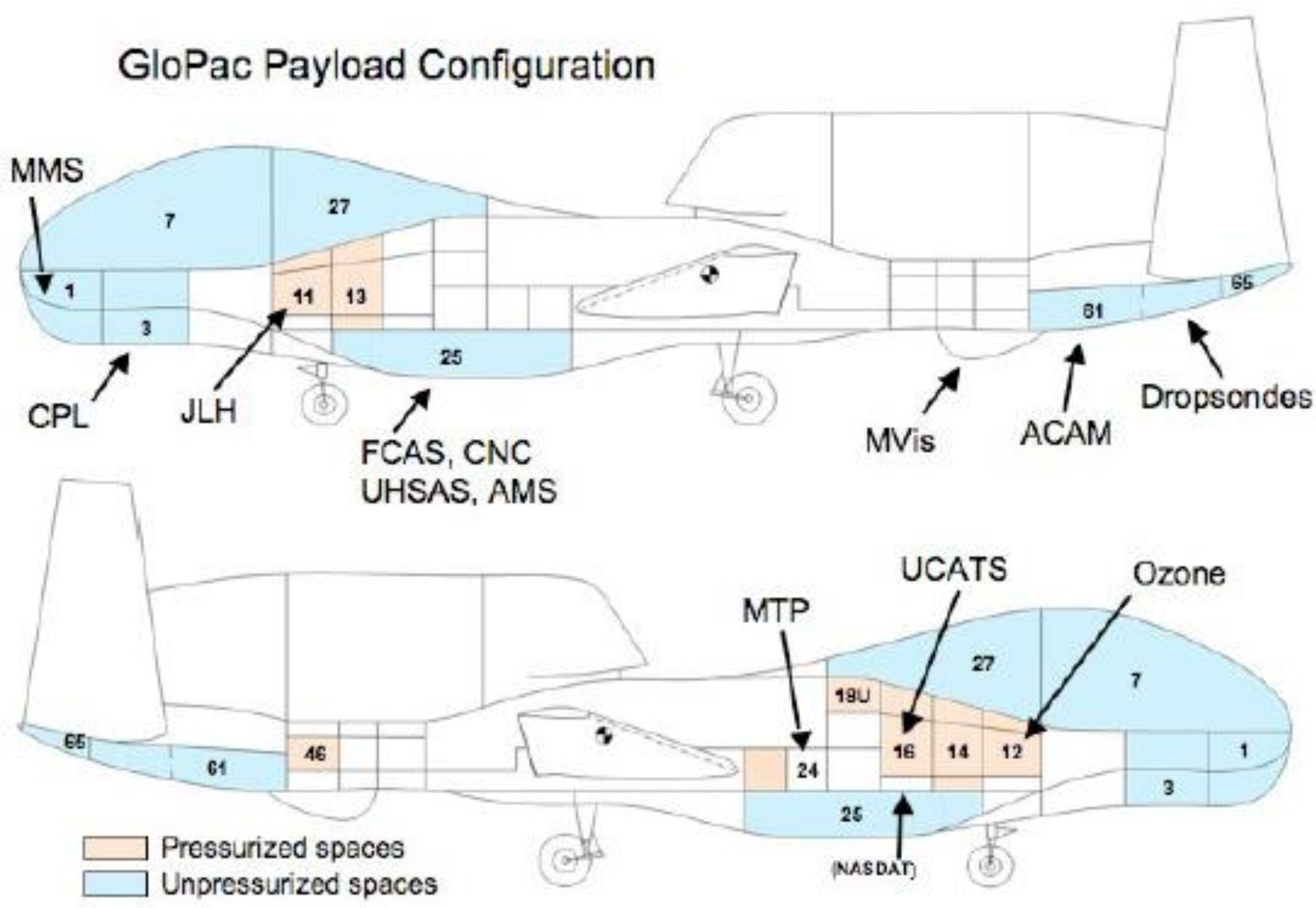
Remote sensors

ACAM UV-Vis spectrometer (column O_3, NO_2)	NASA GSFC (Janz)
CPL Lidar for cloud properties	NASA GSFC (McGill)
MTP microwave temperature profiler	JPL (Mahoney)
HD-VIS camera	NASA Ames (Myers)

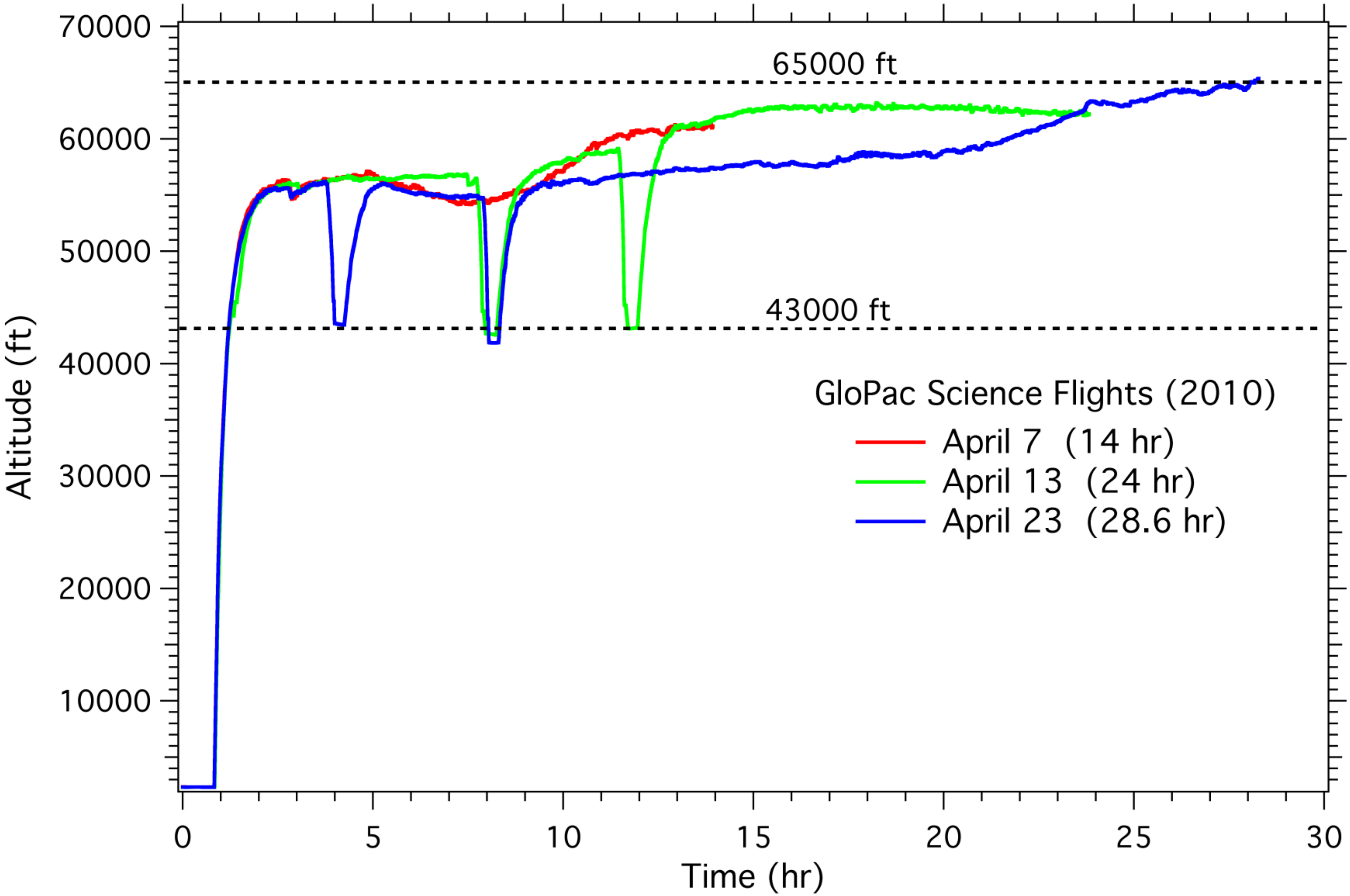
GLOPAC Payload Integration

12 Zones available for payload instrumentation

- About 1500 lbs max in fuselage
- More possible in future wing pods
- Narrow center-of-gravity range

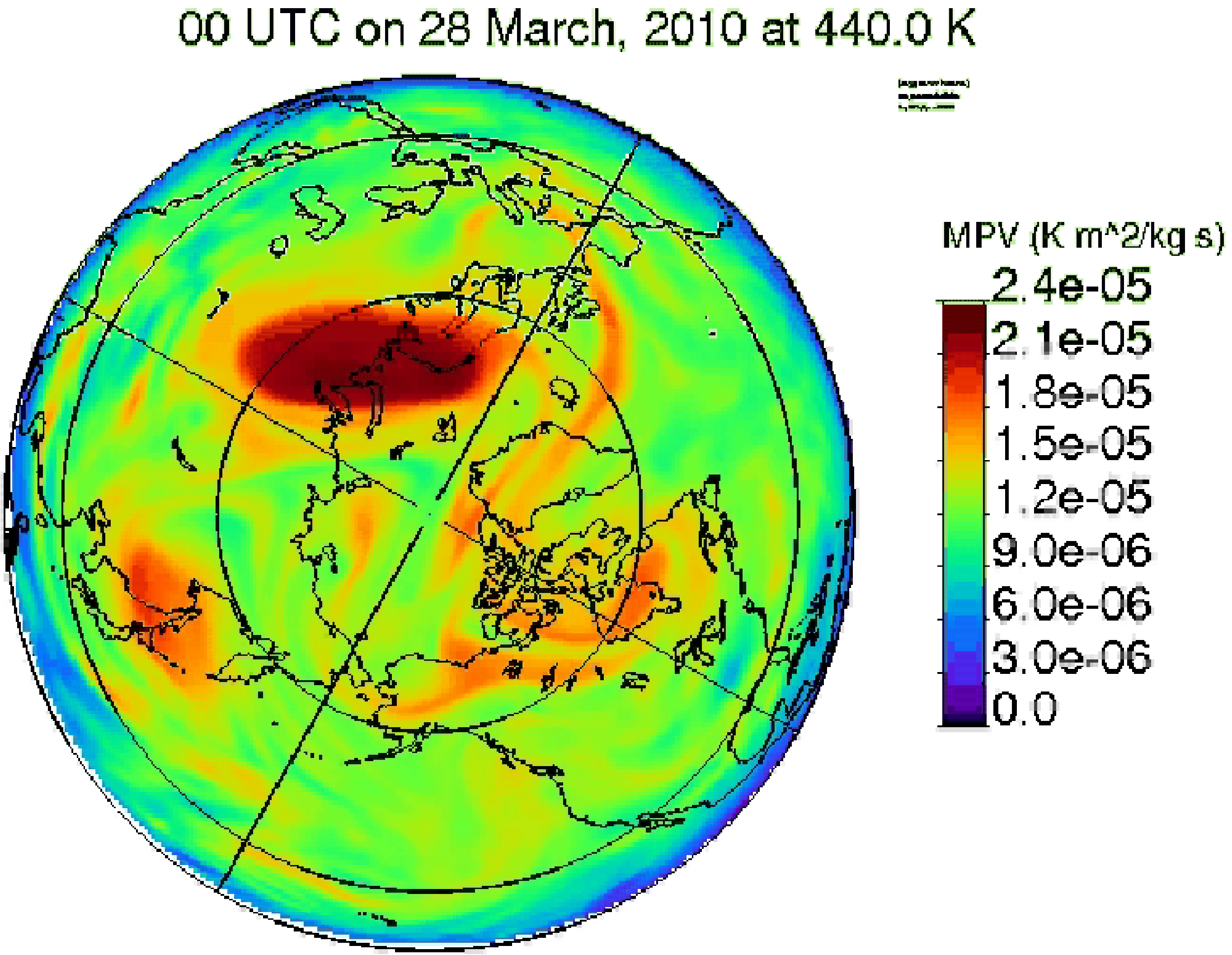


GloPac Altitude Profiles



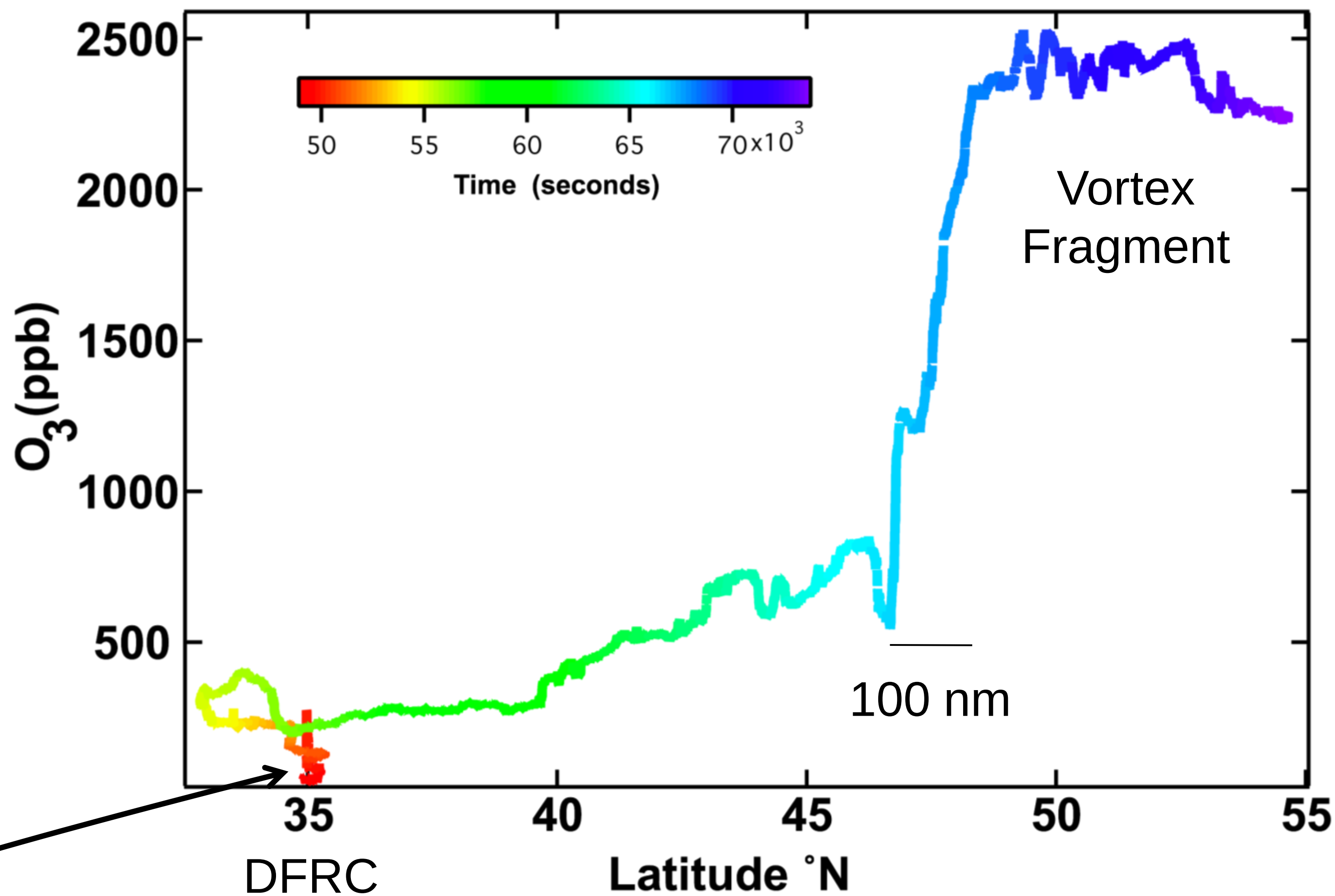
- Duration, altitude ceiling, and vertical profiles maneuvers have all been demonstrated in GloPac.

The stratospheric polar vortex was breaking up during the March-April period



Vortex data provided by the Goddard Modeling and Assimilation Office (Arlindo da Silva, Steven Pawson)

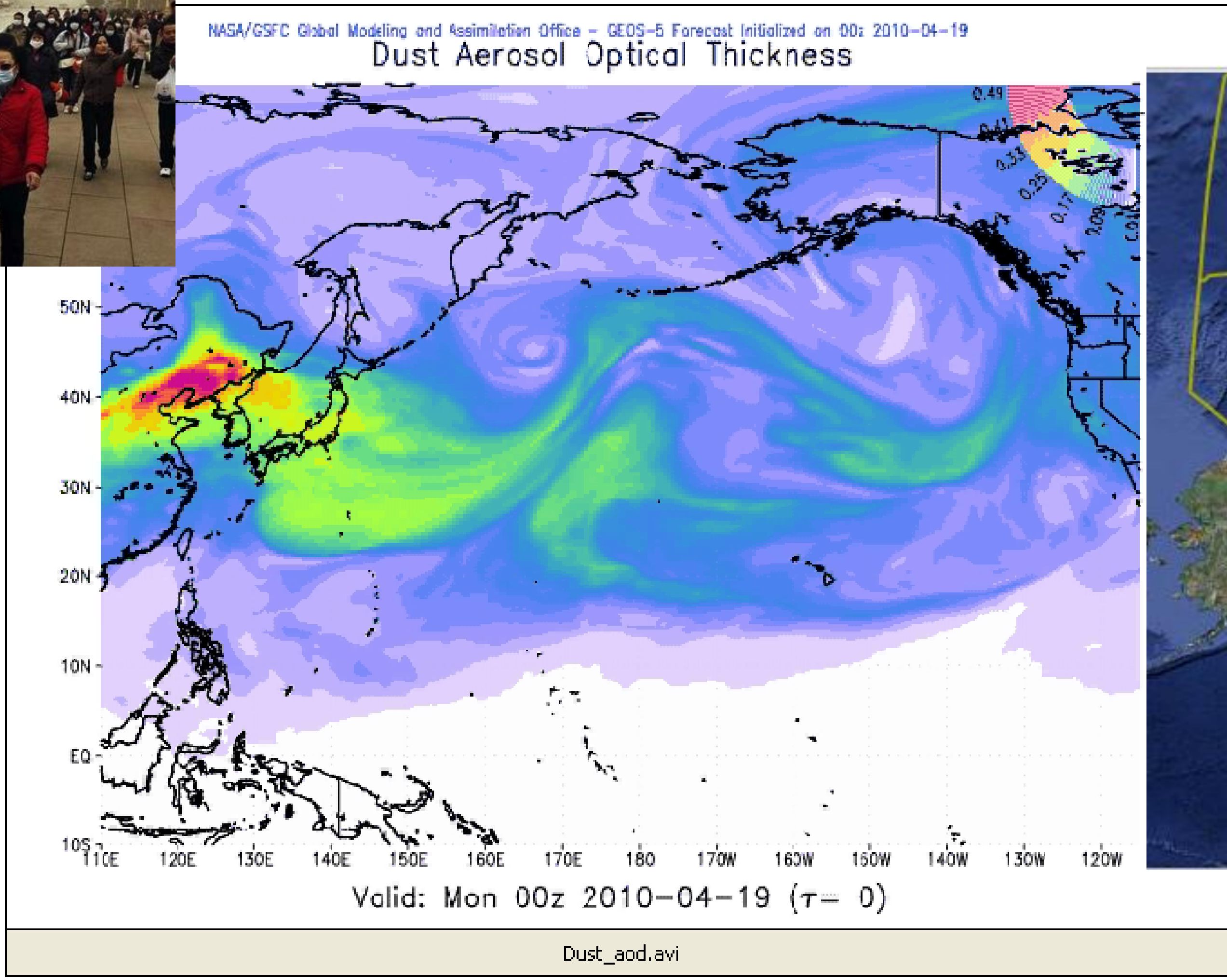
Ozone levels dramatically increased as we passed into the vortex fragment



Takeoff data through troposphere (low altitudes)

NOAA Ozone instrument (Dr. Ru Shan Gao)

Sampling Asian dust transported from the Gobi Desert on 23-24 April

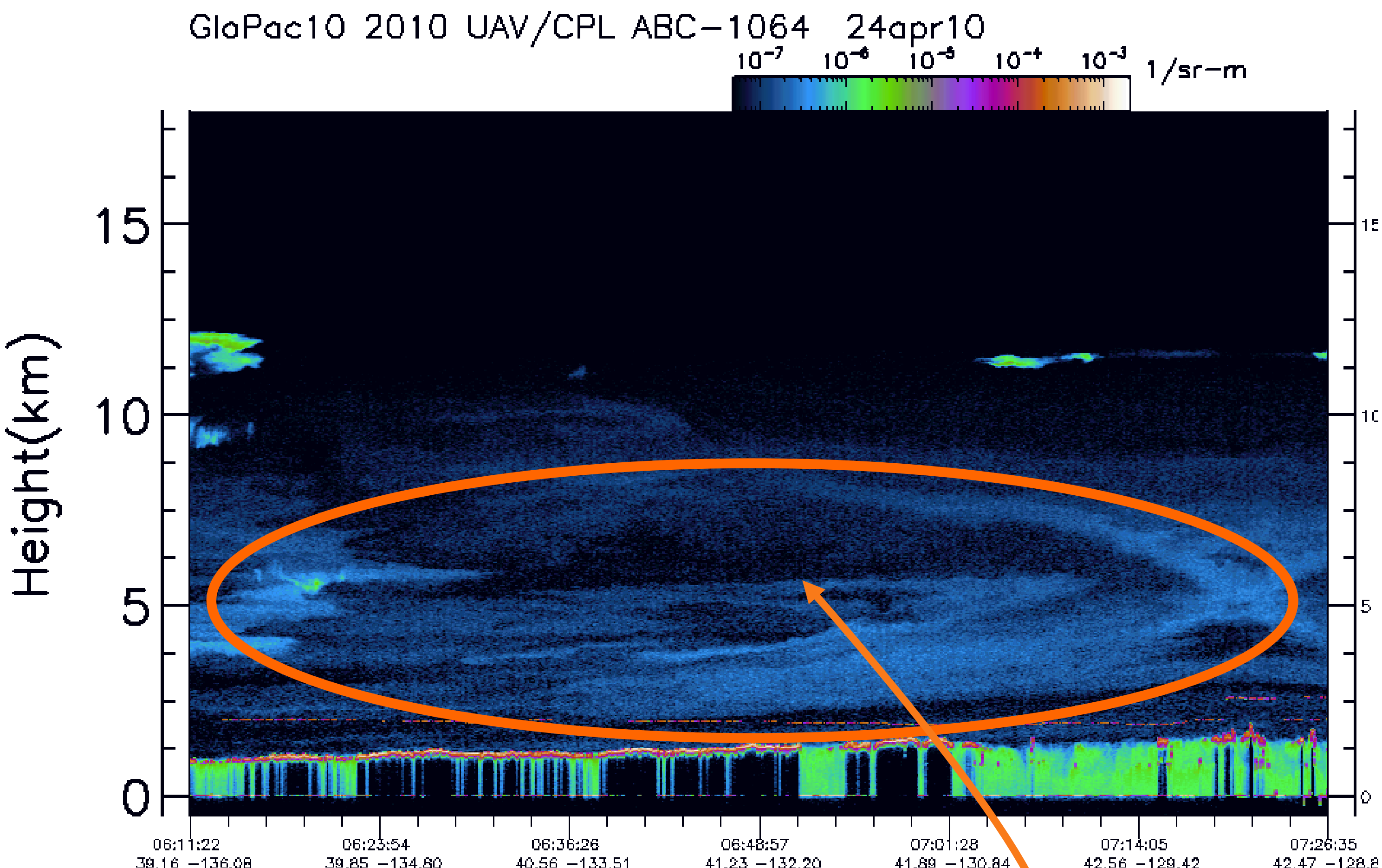


April 23rd

GSFC GMAO model predicts the arrival of a large dust event

P. Colarco, A. Da Silve, NASA GSFC

Cloud Physics Lidar (CPL) Dust cloud sampling 24 April (1064 nm)



Average CPL-derived dust optical depth is 0.04

GEOS-5 model prediction of dust optical depth is ~0.04

M. McGill, NASA GSFC

Global Hawk coordinated flights and satellite validation

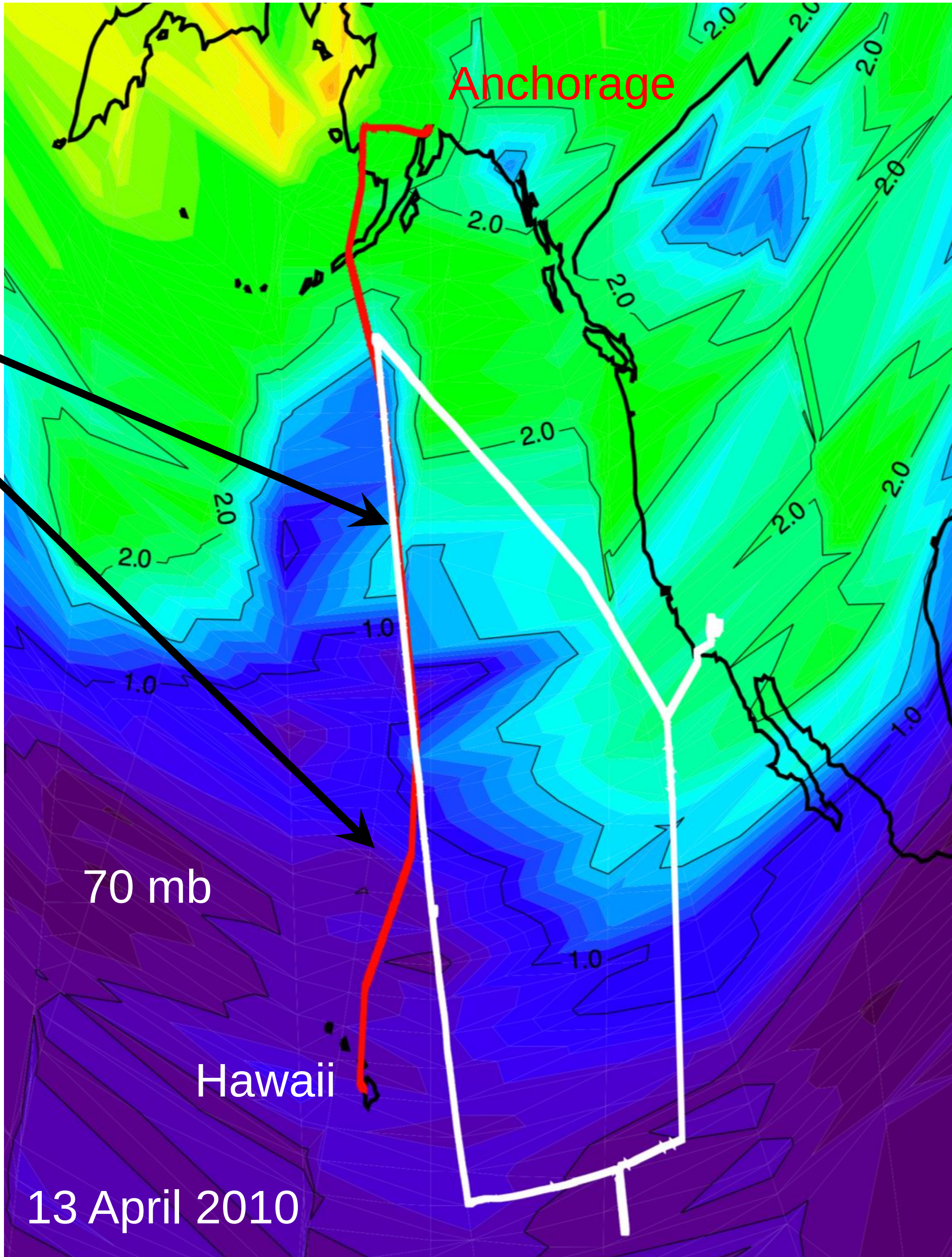
GloPac GH track

HIPPO NSF/NCAR GV

J. Schwarz

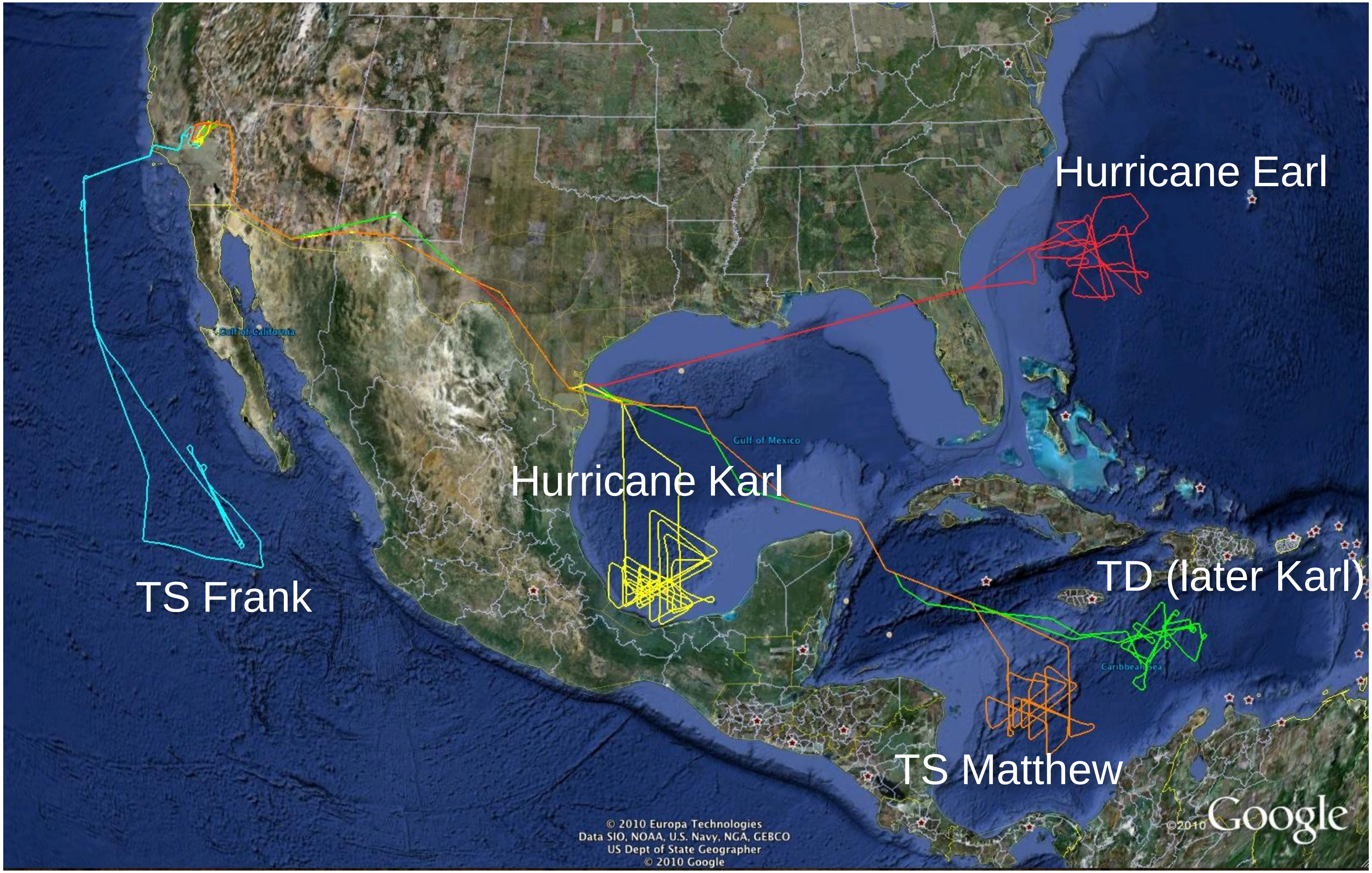
Aura satellite track follows the western side of the GloPac flight.

Ozone field from Aura Microwave Limb Sounder (MLS).



Courtesy of Karen Rosenlof

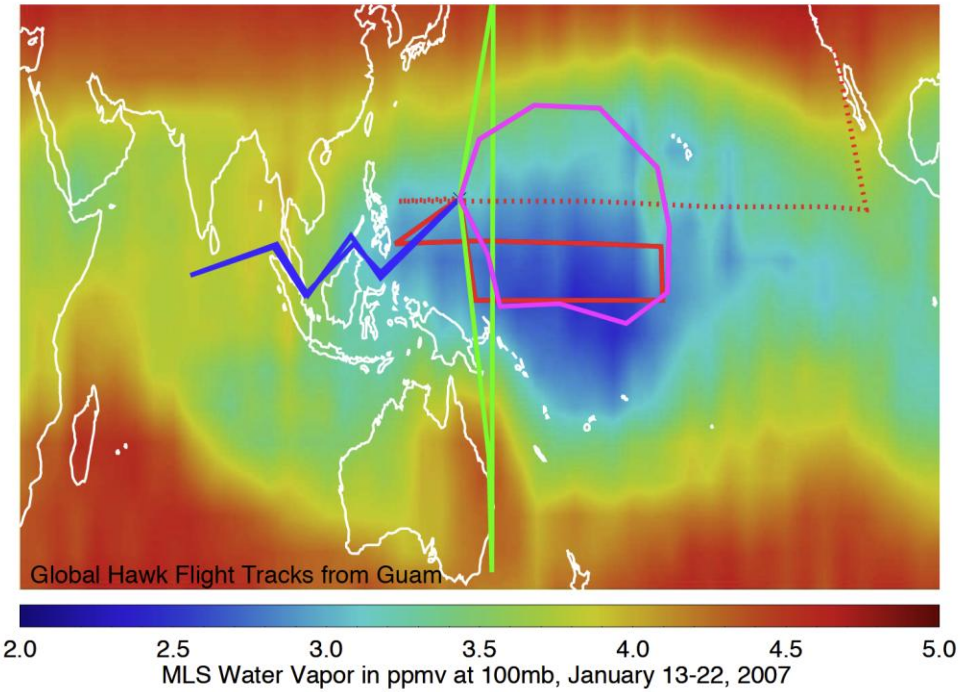
GRIP Mission Recap

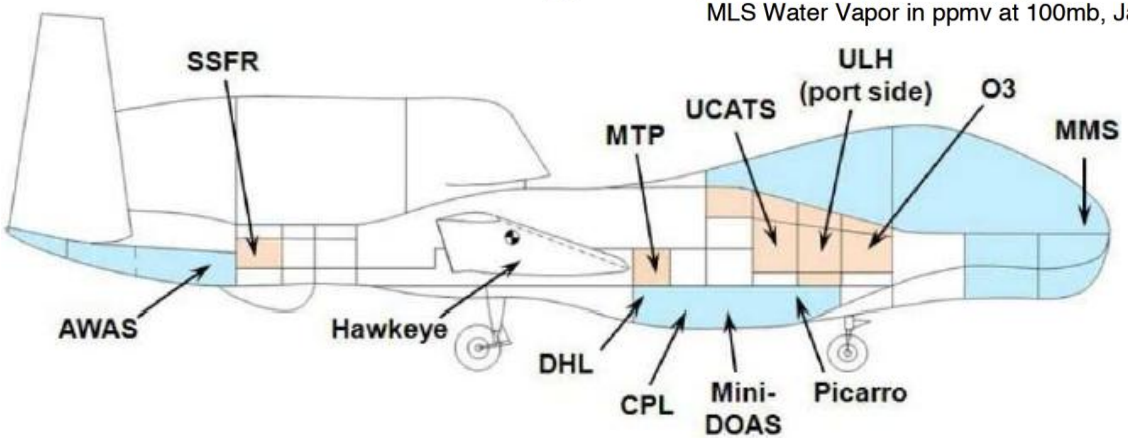


5 Flights, 126 hours, 42,000 nmi – 50$^+$ 'eye' over-flights

NASA Airborne Tropical TRopopause Experment(ATTREX) (2011-2015)

- What are the formation processes of TTL cirrus and how effectively do they dehydrate air entering the stratosphere? Lagrangian flights through TTL cirrus sampling T, H2O, and cloud microphysics
- How might the TTL thermal structure be altered in a changing climate, and what are the potential feedback effects? Use ATTREX measurements to improve GCM representations of processes affecting TTL temperature (tropical waves, radiative budget, convection, etc.)

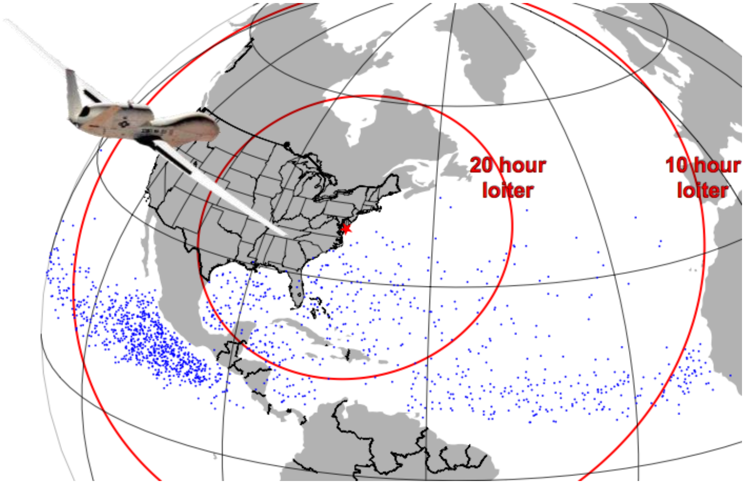


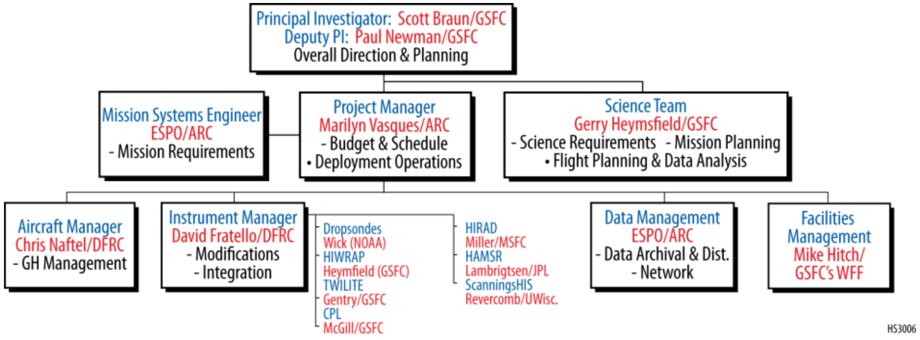


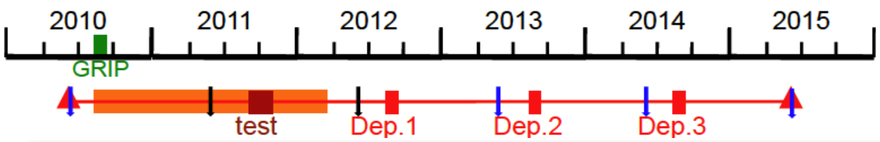
Courtesy of E. Jensen

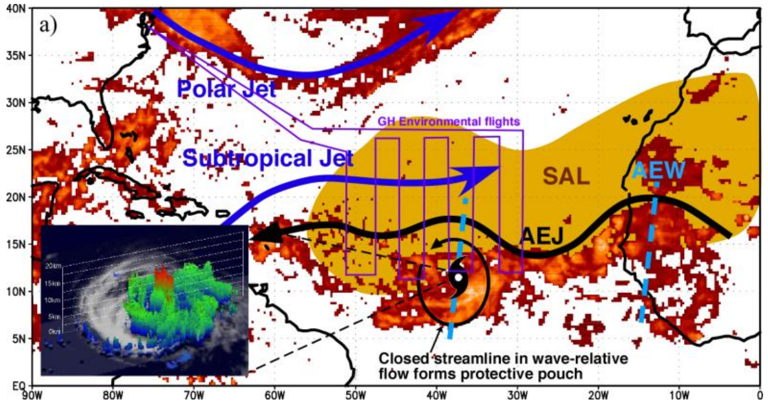
Hurricane and Severe Storm Sentinel (HS^3)

- Scientific Objectives:
  - Hurricane formation and intensification
  - Role of external vs. internal processes
- Platforms: 2 Global Hawk UASs
- Instruments:
  - Overstorm: HIWRAP (GSFC), HIRAD (MSFC), HAMSR (JPL)
  - Environment: S-HIS (UWisc), TWiLiTE (GSFC), CPL (GSFC), and Dropsondes (NOAA)
- Deployments: Aug. 15-Sept. 14, 2012, 2013, 2014
- Ten 30-h flights









Summary Points

- Global Hawk is a unique suborbital platform for Earth science research: Long range at high altitude and real-time remote access
- GloPac set a historical precedent:
  - First demonstration of the Global Hawk for Earth science
  - Exploration of trace gases, aerosols, and dynamics
  - Establish needed capabilities for NASA Science Missions
- Later Missions using the Global Hawk
  - NASA GRIP hurricanes study (just completed)
  - ATTREX – E. Jensen, PI, L. Pfister, Deputy
  - HS3 – Scott Braun, PI, P. Newman, Deputy
- Challenge to the imaginations of the Earth Sciences community: *30 hrs, 1500 lbs, 11000 nm, 20 km*
  - Atmospheric, ecological, and weather research to address global pollution, climate change, ozone depletion, and extreme weather phenomena

Acknowledgments:

DFRC Operations, Pilot, Management, and Met Teams

GloPac Science Team (NASA, NOAA, Universities)

NOAA UAS Program

NASA ARC Earth Sciences Project Office

NASA HQ

Thank you for your attention

T. Tschida, NASA